Viscosity Measurements of Ternary Hydrocarbon Mixtures under Supercritical Conditions

Masoumeh Akhfash, Saif Al Ghafri[S] and Eric May [C]
Fluid Science and Resources Division, School of Mechanical and Chemical Engineering,
University of Western Australia, Perth, WA, Australia
eric.may@uwa.edu.au

Limited information on the transport properties of multi-component hydrocarbon mixtures at conditions above their critical points is currently available. It is important to understand the supercritical behavior of these mixtures to help improve the predictions of current property models which are needed to optimize process designs. This work concentrates on viscosity measurements for ternary mixtures of methane, propane, and heptane of various compositions at pressures between 24 and 31 MPa and temperatures between 200 and 422 K. This was achieved by conducting an extensive set of experiments using a vibrating wire viscometer consisting of a centerless ground tungsten rod with ≈40 mm length and ≈50 µm diameter, clamped at both ends and located in the presence of a static magnetic field. The wire was driven at its resonance frequency using an alternating current and the amplitude of its motion was then determined by observation of the electromagnetically induced voltage through a lock-in amplifier. The viscosity was obtained by stepping the drive signal frequency through the resonance and fitting the measured response to a hydrodynamic response function. The experimental apparatus was calibrated and validated with low and high pressure helium, methane, and propane fluids, where deviations from the ECS model implemented in REFPROP were within -1 % to 2.5 %. For all three hydrocarbon mixtures, the deviations of the measured viscosities from those calculated using the ECS model exhibited a systematic dependence on density. For the ternary 0.85C1+0.1C3+0.05C7, deviations were in the range of -6 % to +10 % over the temperature range of 422 to 200 K. For the ternary 0.8C1+0.1C3+0.1C7, the deviations were around -25 % at the highest temperature (422 K) and -6 % at the lowest temperature (245 K), while for the 0.71C1+0.14C3+0.15C7 mixture, the deviations measured in the range of 1 % to 9 % over the temperature range of 311 to 264 K. These data will help advance models for predicting the viscosity of supercritical hydrocarbon mixtures. Of particular note was the limited stability with time of the mixtures containing large heptane fractions in the absence of agitation, even though they were at supercritical conditions well above the vapor-liquid equilibrium curve. Evidence for these observations will be presented and discussed.